

Lise Meitner, the mother of nuclear fission –

Teacher's guide

The material in this lesson guide, its work sheets and assignments can be used in lessons concerning the following subjects: History (the period prior to, and WW2), Social Science (equality and human rights, specifically discrimination because of ethnicity, religion and/or gender) and Physics (nuclear science). Depending on what subject and emphasis you decide on, different aspects of the material will dominate over others. If possible, integrate all the subjects in to a larger theme, for example “the Atomic era”, this way the pupils will get, not only knowledge in the different subjects, but also a context for this knowledge. The idea is that through the story of one person you can get an insight into a particular period of time and that this knowledge also can teach us something about ourselves and our own time.

Goals

The school will be responsible for ensuring that every pupil who completes compulsory school should (from the Swedish curriculum Lgr 11 for Physics, History and Social Science)

- develop a familiarity with the concepts, models and theories of physics and an understanding of how they are shaped in interaction with, and experiences of investigations of the world. In addition the students shall be given the opportunity to develop the ability to discuss, interpret and produce texts and various forms of aesthetic expression with a scientific content.
- be given conditions to be able to distinguish between scientific and other ways to depict the world, form perspectives on the development of a scientific world view and provided insight into how science and culture influence each other
- provide students with opportunities to acquire a historical reference and a deeper understanding of the present. They should also be given the opportunity to develop a chronological overview of how women and men through the ages have created and transformed societies and cultures.

- stimulate students' curiosity about history and contribute to the development of knowledge about how we can learn about the past through historical sources and encounters with places and people's stories.
- provide students with opportunities to see social issues from different perspectives. In this way, students will be given the opportunity to develop an understanding of their own and other people's lives, the importance of equality, how different interests and opinions arise and are expressed, and how different actors try to influence its development.
- help students develop a familiarity with human rights and with democratic processes and practices

Preperations:

Depending on your preference let the pupils read the text about Lise Meitner on their own, present it in lecture form or read it together. Either way, it is a good idea to make individual copies to each student for future reference.

You also need to decide your own goals for the work since it can be used in such a broad variety of ways, and pick out and copy the appropriate exercises. To complete the exercises the pupils will need access to either textbooks and/or computers to find information. If you want your pupils to use the internet, make sure that you give them access to good, reliable websites and talk to them about source criticism.

Introduction

Lise Meitner, the mother of nuclear fission.

Lise Meitner was born into a Jewish family in Vienna in 1878. She was an excellent student and was given the opportunity to obtain higher education privately with the support of her parents even though girls were not allowed to attend the gymnasium and university until 1899. After an examination in 1901 she started her studies in physics and mathematics at the University of Vienna and became the second woman to obtain a doctoral degree in physics there in 1905. Lise then took off for Berlin to attend the lectures of the great physicist Max Planck. Planck's acceptance of her was an exception to his principle of not accepting women as students, a view he shared with the University of Prussia at this time. Lise became Planck's assistant and met chemist Otto Hahn. Together Lise and Hahn did research and experiments and discovered several new isotopes. Being a woman, Lise did not obtain a salary. She was just considered a "guest" in the department and it was not until 1913, when being offered a position in Prague, that she was formally given a position. After the discovery of the neutron in the early 1930s Lise began experiments together with Hahn trying to create elements heavier than uranium. The same things were simultaneously done by Ernest Rutherford in Britain, Irène Joliot-Curie (daughter of Marie Curie) in France and Enrico Fermi in Italy. Lise was praised by Albert Einstein as the "German Marie Curie". In 1933, when Hitler came to power in Germany, Lise being an Austrian citizen, unlike her fellow German Jewish scientists, could keep on working at the university when the others were forced to leave their work and most of them left Germany. The decision to stay and silently bury herself in her work was something she later regretted. Lise says later that "It was not only stupid but also very wrong that I did not leave at once". After the Anschluss in 1938, Lise was no longer protected by being Austrian and had to escape, now being a German citizen she needed permission to leave the country, something that was not granted for neither Jews nor university professors.

Lise fled to Sweden via the Netherlands and Denmark and got a position in Stockholm, working at Manne Siegbahn's laboratory. She had regular contact with Niels Bohr in Copenhagen whom her nephew Otto Frisch also worked with and with

her colleagues in Germany. Lise and Hahn met in secret in Copenhagen and planned his continuing work with uranium. Christmas of 1938 was spent in Kungälv where Lise was staying at the time. Otto kept on the tradition of spending Christmas with his aunt and it was here, while walking in the beautiful park Fontin, that Lise solved the riddle of nuclear fission. Lise and Otto were eagerly discussing both his work with Bohr in Copenhagen and her correspondence with Hahn and Strassman in Berlin. Hahn and Strassman had kept on with the experiments trying to create new, heavier elements but could not figure out what their results showed. Instead of getting heavier elements they got lighter ones. Lise and Otto took the discovery of Hahn and Strassman and formulated the first theory of how the nucleus of a uranium atom split into smaller parts: barium and krypton. The loss in mass was attributed to the ejection of neutrons and a large amount of energy. The reason that no stable elements existed beyond uranium was because the electric repulsion in the nucleus of this size overcomes the strong nuclear force which holds the atom together. Lise also realised that Einstein's equation, $E=mc^2$, explained the large amount of energy released when breaking an atom. Lise wrote to Hahn and Strassman about her theory on New Year's Day of 1939. Otto talked to Bohr the following day on his return to Copenhagen and Bohr responded with "What idiots we've all been!" The conclusion of Hahn-Meitner-Strassman-Fisch spread fast around the science community and soon the development of nuclear fission was full on.

Since Lise had fled Germany it was impossible for her to publish with Hahn and Strassman who sent in their results without Lise's explanation in December of 1938. She and Otto instead published their correct interpretation of the Hahn-Strassman experiments in *Natur* later in 1939.

Lise was soon to realise the enormous potential of explosive power of a chain reaction, this realisation also spread in the scientific community and the knowledge of the Germans having the potential of building an atomic bomb led to the start of the Manhattan Project in the US. Lise was offered to work in Los Alamos but refused to have anything to do with the bomb. Only a little more than 6 and a half years after Lise and Otto's walk in Kungälv, the bombs fell over Nagasaki and Hiroshima, killing and ruining the lives of several hundred thousands of people and WW2 came to an end.

Lise stayed in Sweden and continued her work with nuclear fission but for the more peaceful use in nuclear power plants. She became a Swedish citizen in 1949 but left for Cambridge in 1959 to be close to Otto and her family. She died in 1968, almost 90 years old. Lise received a lot of awards for her work but was overlooked for her contribution into the discovery of fission by the committee for the Nobel prize, who instead awarded the prize only to Hahn in 1944. Meitner was nominated to receive the prize three times but never did. A 1997 *Physics Today* study concluded that Meitner's being overlooked for her contribution was "a rare instance in which personal negative opinions apparently led to the exclusion of a deserving scientist". She however received the great honor of giving name to element number 109 in 1997 called meitnerium.

Sources:

Sigvard Eklund, Lise Meitner, kärnkraften och Kungälv

<http://www.atomicarchive.com/Bios/Meitner.shtml>

Richard Rhodes, The Making of the Atomic Bomb (1986)

Bengt Forkman Lise Meitner: en levnadsteckning (2006)

Lise Meitner, the mother of nuclear fission.

Goals

As a student you should

- learn about nuclear fission and how the discovery changed the world. You should also learn to discuss the pros and cons of fission and its application.
- learn how theories are formed and how interaction between the scientific community and society as a whole interact.
- get a deeper understanding of how history shape us and our world and get an overview of the events leading up to WW2 and how this affected the lives of ordinary people, and hopefully get a glimpse of life through someone elses eyes.
- get an oppurtunity to see how dependent the development of a single persons life is to things like gender, ethnicity and religion and how people are sometimes discriminated against because of this.
- learn about human rights and the democratic process.

Work description for Lise Meitner

After reading or hearing the story of Lise Meitner your task is to work, either in groups or as individuals with one of the following exercises.

- find out more about fission and how the atom bomb works. Also find out about the long term effects of nuclear weapons, when they have been used, what countries have them and what regulations there are concerning them.
- find out more about fission and how a nuclear power plant works. Also find out about the pros and cons of nuclear power, the problem with storage of burned out fuel and other safety aspects of nuclear power.
- find out what life in Germany was like after 1933 for people like Lise or other people that was persecuted in nazi Germany.

- study the distribution of men versus women as receivers of the different Nobel prizes. Try to explain your findings and think/write about what different career opportunities are considered male/female today.
- Formulate your own task with Lise's story as an inspiration.

Remember to keep in mind the goals for this task as you work with it. Also choose a way to present your work that suits you and/or your group. You are free to work with for example posters, essays, power point or any form of your choice. Remember that the right presentation can bring your work from good to great.



Lise Meitner



The house where Lise stayed in Kungälv in 1938



Memory plaque placed on the house in Kungälv.



Lise and Otto Hahn hard at work in their lab



Hahn and Strassman's equipment from their ground breaking experiments